fidence that no representative of an exclusively exotic fauna figured in the pipe-sculptures of the mound-builders. If we accept the presence of the mammoth or mastodon amongst these carvings, the species which served as models, though now extinct, must be classed with our indigenous fauna. Their knowledge of such animals as the parroquet, the manatus, and possibly the seal and Rocky mountain sheep, does not necessarily indicate any particular migration on the part of that ancient people, but serves to show that their intercourse and commercial relations with other peoples were extensive. As has been previously remarked, however, the artists were apparently well acquainted with some of the birds, mammals and amphibia whose geographical limits were far removed from the upper portion of the Mississippi valley, but which, nevertheless, might have been met with by some of the people in their expeditions. On the other hand, many of the representations were evidently executed from descriptions or rude delineations furnished by those who had seen the originals. The mounds have produced galena from Missouri and the adjacent territory; mica from the spurs of the Alleghany or Rocky mountains; Catlinite from Minnesota; copper from the Lake Superior region; obsidian from Mexico and the Pacific slope of the United States, and marine shells from the Gulf of Mexico, the Atlantic ocean, and also the Dentalium of the Pacific coast.[1] Thus it will be seen that the trade relations of the mound-builders extended over a great extent of territory, in fact, covering the greater portion of the present United States and probably penetrating into British America and Mexico.

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ON THE FLOWERS OF SOLANUM ROSTRATUM AND CASSIA CHAMÆCRISTA.[2]

BY PROFESSOR J. E. TODD.

WITHIN a few years, a plant has been introduced into Southwestern Iowa, which is as unwelcome as it is interesting. It bristles all over on stem, leaves and fruit, with stout, rigid prickles. It is commonly called Texas nettle, as it is supposed to have been brought by the herds of Texas cattle, which in

[1] Vide Ancient Aboriginal Trade in North America, by Dr. Chas. Rau. Smith. Rep., 1872, p. 383.

[2] Read before the Biological Society of Washington, March, 1881.

recent years have been fattened in that region. It is found abundantly in Western Nebraska at present, and although it may have been introduced there in like manner, I presume it is indigenous. It is so put down, I believe, in Coulter's Flora of Colorado.

It has rather conspicuous flowers, of a pure sulphur-yellow color, and of the form represented in the figure. It is a *Solanum*, but very unlike the more familiar forms of the genus. The essential organs are quite unsymmetrical. Four of the stamens are of the normal or usual form, but the fifth, which is on the lower side of the flower, is about twice the length of the others, and has a large, tapering anther, which about the middle is crooked to one side, and its slender apex curved upward as is represented in the figure. This irregularity, doubtless earned for the plant, its cognomen *rostratum*.

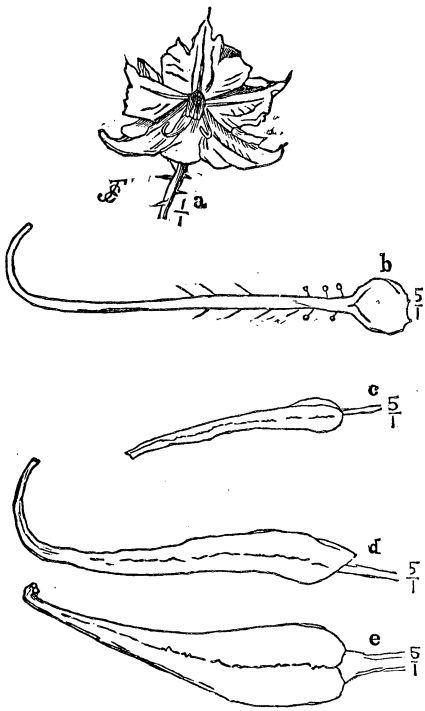

FIG. 1.—*Solanum rostratum*. *a*, flower (natural size); *b*, pistil; *c*, a short stamen; *d*. lateral view of the long stamen, and *e*, view of the same from above.

The anthers open by terminal chinks or pores, as is common to this genus. The long anther shows considerable elasticity, and in its movements throws a puff of pollen from its apex, which, as will be seen, is turned upward and at right angles with its axis.

The pistil, as will be seen from the figure, is turned so as to resemble in general form, size and position, the long anther just described, with this exception, that it turns toward the opposite side of the flower. Moreover, the pistil and longer stamen, in different flowers, exchange directions, so that in some the pistil turns to the right hand, and the stamen to the left, and in others *vice versa*. We will, for convenience, call the flowers in which the pistil turns to the right hand, facing as the flower,

right-handed, and those in which it turns to the left, left-handed. The figure represents a left-handed flower. With a little examination, it is found that there is a very simple law deciding whether any given flower, from its position, should be right-handed or left-handed. In the examination of scores of flowers I found no exception to this law. The flowers are arranged in simple, bractless racemes, which extend in a horizontal position. The flowers, consequently, are arranged on each side of the axis.

The law referred to is this. The pistil, in any flower, turns towards the axis of the raceme. It follows from this, that successive flowers on the same raceme have their pistils turned toward opposite sides. It is also a fact of observation, that the flowers of a cluster on any one branch, and opening about the same time, are either all right-handed or all left-handed. Any plant, however, if it is at all large, exhibits right and left-handed flowers in about equal numbers.

Of five plants observed:

No.	1	had	5	pistils	left-handed,	and	4	right-handed.	
"	2	"	3	"	"	"	1	"	"
"	3	"	1	"	"	"	2	"	"
"	4	"	3	"	"	"	3	"	"
"	5	"	3	"	"	"	4	"	"

The advantage in all this is so obvious that it scarcely needs explanation. It is like most irregularities in flowers, a contrivance for cross-fertilization. After considerable watching, I had noticed no insects visiting the flowers, except a small humble-bee, and this seemed quite attentive. The weight of the bee so springs down the flower, that it is quite difficult, on account of the large flexible corolla, to see just what is done, but repeated observations led me, quite satisfactorily, to this conclusion. The bee seeks the pollen—for the flowers have neither nectar nor odor—and this she uniformly gets from the four shorter stamens; never, so far as I could determine, from the larger one. This she does by seizing each one, near its base, between her mandibles, and with a sort of milking motion crowds the pollen out of the terminal pores; meanwhile, by the movements of her feet, the larger stamen is repeatedly sprung backwards, and as often throws a cloud of pollen on one side of her body; this in a right-handed flower. When she passes to a left-handed flower, which, as was explained above, is very likely not to be on the same plant, the pollen is carried directly to the pistil of that flower, and so on. We have here,

therefore, a novel apparatus for cross-fertilization, quite distinct from those that have been most commonly noticed.

A few days after having noticed the peculiarities of *Solanum rostratum*, my attention was attracted to the asymmetry of the flowers of the more common plant, *Cassia chamæcrista*. Its appearance, when fully open, as in early morning, is shown in the figure. The points that are of special interest to us, are the sickle-shaped pistil, the stamens with long, rigid anthers, opening by terminal pores, and most of them pointed toward the incurved petal, which is always on the opposite side from the pistil, as is shown in the figure. A vertical line let fall across the flower, in its natural position, uniformly falls midway between the two. So we may here speak of the flowers as right-handed or left-handed, as before, according to the position of the pistil. As the inflorescence is less regular than in *S. rostratum*, we have been unable to discover any definite law, as in that case, but different plants have about an equal share of right and left-handed flowers. Observations on some plants that were in rather a dilapidated condition, resulted as follows:

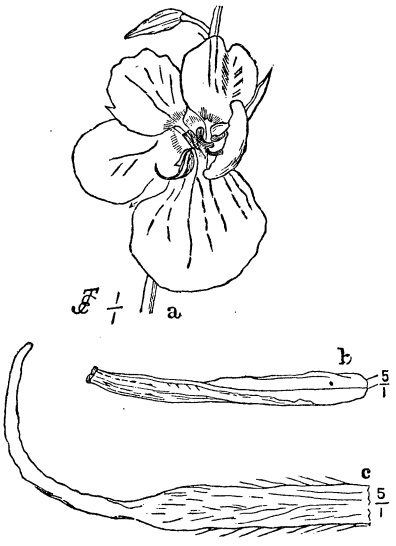

FIG. 2.—*Cassia chamæcrista*, *a*, flower (natural size); *b*, a stamen; *c*, pistil.

Plant	No.	1	had	6	right-handed	flowers	and	4	left-handed.		
"	"	2	"	4	"	"	"	"	2	"	"
"	"	3	"	2	"	"	"	"	0	"	"
"	"	4	"	1	"	"	"	"	2	"	"

I found these flowers also visited mainly by a small humble-bee, and judge that they gather pollen in a similar way to that noticed in the *Solanum*. The flowers are nectarless and odorless. The advantage is not so obvious in this arrangement as in the *Solanum*, and I have not had opportunity to study it quite as closely and carefully, but I consider the following explanation the most probable.

In gathering the pollen, some grains are dropped on the incurved petal, and by it made to adhere to parts of the bee, and to such parts in a right-handed flower as will carry it to the stigma of a left-handed flower, and *vice versa.*

So much for the observations upon the plants themselves. Let us trace their more marked peculiarities in related plants, and, if possible, find some hint as to their origin.[1]

In *Solanum rostratum* the particulars in which it differs from the normal form of the genus, are three, viz: (1) The long recurved style; (2) the elongation and enlargement of the lower stamen; and (3) the crooking of them toward opposite sides of the flower. In examining kindred species of this most numerous genus, we find that in our common *S. nigrum* in Southern California, there appears a variety, *S. Dillenii*, which sometimes has its style exerted, and sometimes has it short as in the common *nigrum.* Another, *S. nodiflorum*, in Arizona, which "generally has this feature," passes into *S. Douglassi* which is found at Santa Barbara, Cal. The development of this character seems to attend, and perhaps depends upon, the change of the flowers from a drooping attitude, as in the typical *nigrum*, to a more erect position. The obliquity of the stamens, or their vertical asymmetry, as it might be called, appears in *S. tuberosum* sometimes. I have observed it in the "peach-blow" variety; I have observed it more frequently in *S. Carolinense.* The extreme form, however, which we have found in *S. rostratum*, is confined to the sub-

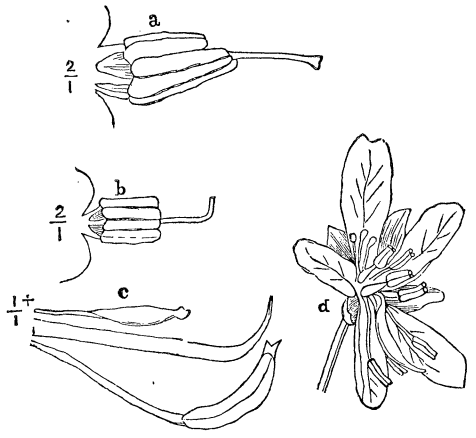

FIG. 3.—*a*, stamens and pistil of *Solanum tuberosum*, unusual form; *b*, do. of *S. nigrum* var. *Dillenii*; *c*, do. of *Cassia occidentalis*; *d*, flower of *C. acutifolia*, after J. Murray. Note.—*b* and *c* were drawn from dry specimens.

[1] This work would necessarily have been very incomplete, had not the library and herbarium of the U. S. Department of Agriculture been freely opened to me by the kindness of Dr. Vasey, to whom I would thus acknowledge my indebtedness.

genera *Androcera* and *Nycterium*. The first has but one long stamen, and *S. rostratum* may be taken as its type. This subgenus is confined to tropical America. *Nycterium* contains species most of which have three long stamens, but some have only one. A table of the species and their distribution is as follows:

tridynamus, obtusilobum and amazonum	}	3 lower stamens longer,			Mexico.
Wrightii	3	"	"	"	East Indies.
vespertilio	1	"	"	"	Canaries.
dubium	1	"	"	"	Arabia and North Africa.

Of the lateral asymmetry I cannot speak, for so far as I can learn, it has not been noted. In the case of *Cassia chamæcrista*, the unsymmetrical features are (1) the curved style, (2) the oblique stamens, (3) their abnormal number, and (4) the incurved petal. The first is not peculiar, but is found in nearly all representatives of the order *Leguminosæ*. The second and fourth peculiarities are such as are easily overlooked, and have not, so far as I find, been noted of other species. The third peculiarity becomes significant when we compare this species with a typical one of the genus, such as the one shown in the figure of *C. acutifolia*, which may also represent in general, *Marylandica* and *occidentalis*. Here (Fig. 2) we usually have seven fertile stamens; in that (Fig. 3 *d*) we find the other three of the normal number ten, present, but sterile, as if to indicate that some of the seven are derived from the longer ones of the typical form. One or two of them in *chamæcrista*, instead of following the oblique position of the rest, sometimes stretch out on the side of the pistil.

The advantages of the arrangement in *chamæcrista* for securing cross-fertilization over the more common form of the *Cassiæ*, as in *acutifolia* and *occidentalis*, I think may be seen without further explanation. Moreover, if the insects visit the flowers for pollen, we can readily see the advantage in having the stamens of unequal length, and hence the development by natural selection, of the *Androcera* form of *Solanum*, and the typical *Cassia* from among the *Cæsalpinieæ*

Before leaving the subjects suggested by these flowers, I would indicate several points, and not having time to discuss them more fully, we will leave them in the form of queries.

1. These similar modifications occur in utterly diverse families, having similar geographical distribution, viz: in tropical regions, and perhaps the limitations may be further narrowed to the drier

parts of these regions. May this not indicate that certain physical influences have primarily induced the variations which have been developed into perfect adaptations?

2. May not heliotropism, or the retarding effect of light upon the formation of tissue, partly explain the greater development of the lower stamens, the shortening of the middle, and the abortion of the upper; and may it not also explain the upward curving of the styles and lower stamens in these plants?

3. May not the mechanical action of the insect have some connection with the obliquity of the *C. chamæcrista* flower, and the divergence of the styles and stamens? *C. chamæcrista* is like the typical form turned downward and to one side.

4. In these plants we have found a lack of bilateral symmetry, and we have found it attended with a regular exchange of sides, and that to accomplish a special purpose. Is this commonly so in plants thus irregular, such as the *Cannaceæ* and *Zingiberaceæ?*

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IS LIMULUS AN ARACHNID?

BY A. S. PACKARD, JR.

IN an article by Professor E. R. Lankester in the *Quarterly Journal of Microscopical Science*, for July and October, 1881, entitled "Limulus an Arachnid," the author, distinguished for his histological and embryological papers especially relating to molusks and Cœlenterates, takes the ground that Limulus, or the horse-shoe or king crab, "is best understood as an aquatic scorpion, and the scorpion and its allies as terrestrial modifications of the king crab," and on p. 507 he makes the following startling announcement: "That the king crab is as closely related to the scorpion as is the spider has for years been an open secret, which has escaped notice by something like fatality." While appreciating the thorough and critical nature of the learned author's work, especially observable in his excellent paper on the structure of Apus, we venture to assert that in regard to the systematic position of Limulus, Professor Lankester has mistaken interesting analogies for affinities, and has on quite insufficient and at times wholly hypothetical grounds rashly overlooked the most solid facts, and safe inductions from such facts, and arrived at very forced and it seems to us strange and quite untenable conclusions.

At the outset, it will be remembered that Limulus differs from